

# HALF VOLTAGE GENERATOR FOR USE IN SEMICONDUCTOR MEMORY DEVICE

This application claims priority from Korean Application No. 2002-64245 filed  
5 October 21, 2002, incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a semiconductor device and, more particularly, to a  
10 half voltage generator for use in a semiconductor memory device.

### 2. Description of the Related Art

In a read operation of a semiconductor memory device, data stored in a memory cell  
is sensed and amplified by a sense amplifier (S/A) that is connected to a bitline (BL) and a  
15 complementary bitline (BLB), and externally provided. After the S/A's sense and  
amplification operations, the device precharges the BL and BLB to a predetermined level.  
The precharge operation is classified broadly into two methods. The first method is to  
precharge the BL to a voltage source VCC and the BLB to a ground voltage VSS. The  
second method is to precharge the BL and BLB to a half voltage source VCC or Half VCC.  
20 The first method is called a full voltage source precharge and the second method is called a  
half voltage source precharge. The full VCC precharge consumes more power than the half  
VCC precharge, thus most of semiconductor memory devices employ the half VCC  
precharge method. To execute the half VCC precharge method, a half voltage source (half  
VCC) generator is needed within the chip.

25 FIG. 1 shows a circuit diagram of a conventional half VCC generator. Referring to  
FIG. 1, the half VCC generator includes two MOS resistances MP0 and MN0, two diodes  
MN1 and MP1, a pull-up driver MN2, and a pull-down driver MP2. A voltage at a node  
NDA is set by a resistance ratio of the MOS resistances MP0 and MN0, and the drivers  
voltage of the node NDA is applied to each of gates of the pull-up and pull-down drivers  
30 MN2, MP2 through two diodes MP1 and MN1. The pull-up and pull-down drivers operate  
by a voltage level applied to each gate thereof to thus output a half voltage VBL. That is, a  
level of the outputted VBL is traced to a voltage level of the node NDA.

In FIG. 1, the VBL is commonly fed back to each of gates of the two MOS resistances  
MP0 and MN0. When a level of the VBL becomes a half level of the voltage source VCC

and thus a size of transistors of the MOS resistances MP0 and MN0 is adjusted so that the voltage level of the NDA becomes the half VCC, a voltage by a threshold of respective diodes is applied to each of gates of the pull-up and pull-down drivers MN2 and MP2. To set the VBL, the size of the MOS transistors MP0 and MN0 is adjusted so that the voltage at NDA becomes half VCC. Once a level of the outputted VBL is deviated from the half VCC, resistance values of the two MOS resistances MP0 and MN0 are changed by a feedback operation, and thus a voltage level of the NDA is also changed. The changed voltage level changes a gate voltage of the pull-up and pull-down drivers MN2 and MP2, to thus stably maintain a level of the VBL of an output terminal as a level of the half VCC.

A tendency toward improved semiconductor technology and for a low-power memory, results in lowering VCC. The conventional half VCC generator, however, is limited by the two transistors MP0 and MN0 being used as the resistances. Transistors MP0 and MN0 might turn off as VCC is lower than a predetermined level. In other words, the two transistors MP0 and MN0 receive the half VCC as a gate voltage and this voltage is gradually lowered, resulting in one of the transistors turning off thereby improperly operating the voltage generator.

The half VCC generator shown in FIG. 1 has an advantage that the two drivers MN2 and MP2 do not turn on at the same time when a level of the half voltage is above a threshold voltage  $V_t$  of the transistor. Thus a standby current is small and a level of a determined half voltage can be maintained more precisely.

FIG. 2 shows another conventional half Vcc generator. Referring to FIG. 2, the voltage generator employs two differential amplifiers DA1 and DA2 to drive driver transistors. Thus, the voltage generator has a great driving capability as compared with the circuit of FIG. 1. Also the circuit of FIG. 2 has a low-voltage limitation of  $1V_t + V_{ds\_sat}$  in comparison with that the circuit of FIG. 1, which has a low-voltage limitation of  $2V_t$ . There is, therefore, an advantage that the circuit of FIG. 2 has a low limitation for the low-voltage and a high driving force, but a disadvantage that both transistors MP12 and MN12 turn "ON" at the same time. This causes a leakage current to flow that causes the output voltage at node NDB to oscillate.

The conventional half voltage source generators, therefore, might have a low driving capability, not be capable of a low-voltage operation, contain a leakage current flow, and cause oscillation at an output node. Accordingly, a need exists for an improved half voltage source generator.

## SUMMARY OF THE INVENTION

According to exemplary embodiments of the present invention, a half voltage source generator accurately provides a half voltage source with a high driving force, maintains a stabilized half voltage source level, responds speedily to a load variation of an output node, and is reliable and stable.

According to an exemplary embodiment of the present invention, a voltage generator for use in a semiconductor memory device provides a stabilized output voltage of half a supply voltage  $V_{cc}$ . The voltage generator includes a reference voltage generator capable of generating first and second reference voltages. A differential amplification drive circuit is capable of generating an output voltage responsive to the first and second reference voltages. A resistance/diode reference voltage generator is capable of generating third and fourth reference voltages. And a pull-up/down drive is capable of changing the output voltage responsive to the third and fourth reference voltages. The resulting voltage generator provides a stable and accurate output voltage that is resistant to output load variations.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will become readily apparent from the description of exemplary embodiments that follows with reference to the accompanying drawings.

FIGS. 1 and 2 are circuit diagrams of conventional half voltage source generators.

FIGS. 3 through 5 are circuit diagrams of embodiments of half voltage source generators according to the present invention.

## PREFERRED EMBODIMENT OF THE INVENTION

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to FIGS. 3 through 5.

The elements described in FIGS. 3 through 5 in accordance with the exemplary embodiments of the present invention, which are similar to those described with respect to FIGS. 1 and 2, will be provided with the same or similar reference symbols.

FIGS. 3 to 5 are circuit diagrams of half voltage source generators of various exemplary embodiments according to the present invention.

Referring first to FIG. 3, the generator includes a reference voltage generator 30, a differential amplification drive 31, a pull-up/down drive 32, and a MOS resistance/diode reference voltage generator 33.

The reference voltage generator 30 is constructed of a first resistance R0 that is connected between a power terminal and a first node for generating a first reference voltage Vref1, a second resistance R1 that is connected between the first node and a second node for generating a second reference voltage Vref2, and a third resistance R2 that is connected  
5 between the second node and a ground terminal.

The differential amplification drive 31 includes a first differential amplifier DA1. The first differential amplifier DA1 has one input coupled with the second node and another input coupled with an output terminal that is connected thereto in a negative feedback type. A second differential amplifier DA2 has one input connected to the first node and another  
10 input connected to the output terminal in a negative feedback type. A first pMOS transistor MP12 has a source coupled with the power terminal, a drain coupled with the output terminal, and has a gate coupled to an output of the first differential amplifier. And a first nMOS transistor MN12 having a drain connected to the output terminal, a source connected to the ground terminal, and a gate connected to an output of the second differential amplifier.

15 The pull-up/down drive 32 comprises a second nMOS transistor MN2 having a drain coupled with the power terminal and a source connected to the output terminal. A second pMOS transistor MP2 has a source coupled with the output terminal and a drain coupled with the ground terminal.

The MOS resistance/diode reference voltage generator 33 includes a third pMOS  
20 transistor MP0 having a source connected to the power terminal, a gate coupled with the output terminal, and a drain coupled with a gate of the second nMOS transistor MN2. A third nMOS transistor MN1 has a drain and gate commonly connected to the drain of the third pMOS transistor MP0. A fourth pMOS transistor MP1 has a source connected to a source of the third nMOS transistor MN1 and a gate and drain coupled with the gate of the second  
25 pMOS transistor MP2. And a fourth nMOS transistor is MN0 having a coupled with the output terminal, a drain coupled with the drain of the fourth pMOS transistor MP1, and a source coupled with the ground terminal.

In the circuit of FIG. 3, the first reference voltage Vref1 is equal to  $(V_{cc} \cdot (R_1 + R_2)) / (R_0 + R_1 + R_2)$ . If  $R_0 = R_2$  and  $R_1 \ll R_0, R_2$ , Vref1 is greater than the half  
30 VCC by  $R_1 / ((R_0 + R_1 + R_2) / 2)$ . And, the Vref2 is smaller than the half Vcc by  $R_1 / ((R_0 + R_1 + R_2) / 2)$ . The first differential amplifier DA1, therefore, a low state output the drive transistor MP12 when a level of the output terminal VBL is smaller than  $V_{cc} / 2 - R_1 / ((R_0 + R_1 + R_2) / 2)$ . A charge is supplied from the power terminal to a VBL node to increase a voltage at VBL. The second differential amplifier DA2 has a high state output turning on

the drive transistor MN12 when the VBL is higher than  $V_{cc}/2 + R1/((R0+R1+R2)/2)$ . A charge flows from the VBL node to the ground terminal to decrease a voltage of the VBL. Put differently, if the VBL node is at a voltage within  $V_{cc}/2 \pm R1/((R0+R1+R2)/2)$ , the transistors MP12 and MN12 are simultaneously turned off and the VBL node floats. This prevents a leakage current from flowing from the transistor MP12 to the transistor MN12 by an offset of the differential amplifier.

Current developments in semiconductor process technology tend toward device scale down to gradually increase an offset of the differential amplifier. To compensate for this offset, a floating section of the VBL node must become larger.

The voltage generator of FIG. 3 including the pull-up/down drive 32 and the MOS resistance/diode reference voltage generator 33, does not operate with two transistors simultaneously turned on because a gate voltage of the driver transistors MN2 and MP2 always changes in the same direction as the VBL node voltage. Thus, the half  $V_{cc}$  voltage generator of can accurately maintain the VBL node at half the  $V_{CC}$  level.

As described above, the circuit of FIG. 3 has high driving force and accurately maintains a half  $V_{cc}$  level.

Even though the resistance  $R1$  used in the circuit of FIG. 3 is provided as a large value in comparison with a resistance value provided in FIG. 1, the VBL node is maintained with a stabilized level without a floating section by combining two types of voltage generators.

Other exemplary embodiments of the present invention are shown in FIGS. 4 and 5. These diagrams show circuits that use the high driving force of the half  $V_{cc}$  voltage generator using the differential amplifier together with a resistance of a diode connection type so as to prevent the VBL from floating.

Referring to FIG. 4, the pull-up/down drive 32 shown in FIG. 3 is omitted. N-type MOS diodes MN21 and MN22 are connectively configured, functioning as a resistance element instead of the MOS resistance/diode reference voltage generator 33.

Referring to FIG. 5, the pull-up/down drive 32 of FIG. 3 is omitted. P-type MOS diodes MP31 and MP32 functioning as a resistance element instead of the MOS resistance/diode reference voltage generator 33 are configured connectively.

In FIGS. 4 and 5, the VBL node maintains a stabilized level without the "floating" section, thereby obtaining a high driving force and an exact preserving force of the half  $V_{cc}$  level.

The half Vcc generator responds to a load variation of an output node at a high speed and simultaneously maintains a stabilized half voltage level, whereby providing a high driving force and an accurate level of a half source voltage.

5 Although the present invention was described in detail above in connection with the preferred embodiments thereof, the scope of the invention is not so limited. Rather, various changes and modifications of the preferred embodiments, as will become apparent to those of ordinary skill in the art, are seen to be within the true spirit and scope of the invention as defined by the appended claims. According to some cases, it is, of course, valid that an internal connection configuration of a circuit may become different therefrom.

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